

Exercises for group work

Exercises for focusing on important aspects of today's topics:

**Q1.** What do ribosomes consist of?

*Ribosomal RNA (rRNA) and proteins. In its active form, ribosomes consist of a large and a small subunit, which are separated when the ribosome is not translating.*

**Q2.** How does an RNA polymerase differ from a DNA polymerase?

- *The RNA polymerase requires a promoter sequence on the DNA, whereas the DNA polymerase requires an RNA or DNA primer.*
- *The RNA polymerase can separate the DNA strands on its own, whereas the DNA polymerase requires help from a helicase.*
- *It is only the DNA polymerase that can detect and correct mistakes (proof reading) if the transcription is incorrect.*

**Q3.** What are the building blocks used by the RNA polymerase?

- *A template strand and NTP's (ATP, GTP, CTP, and UTP).*

**Q4.** What is the function of tRNA?

*tRNA is involved in the translation process of mRNA to protein. It scans the codons on the mRNA chain and can bind via basepairing to the three bases of a specific codon, if the bases in the anticodon of the tRNA are complementary. At the other end of the tRNA molecule, it carries an amino acid that corresponds to the specific codon. The amino acid is transferred to the growing polypeptide chain in the ribosome, thereby extending the polypeptide chain.*

**Q5.** A reading frame is a sequence of codons (that is, nucleotide triplets). How does a ribosome decide which reading frame is the correct one?

*In prokaryotes, the small ribosomal subunit recognizes the ribosome binding site (Shine-Dalgarno sequence) at a particular distance upstream of the start codon. In eukaryotes, the small ribosomal subunit binds to the 5' end of the mRNA and then scans the mRNA in the 5' -> 3' direction until it encounters a start codon. In the next step, a tRNA carrying methionine will bind to the start codon. This constitutes the initiation complex.*

**Q6.** How does the machinery of a cell decide whether a newly synthesized protein should be transported into the endoplasmatic reticulum or end up in the cytoplasm?

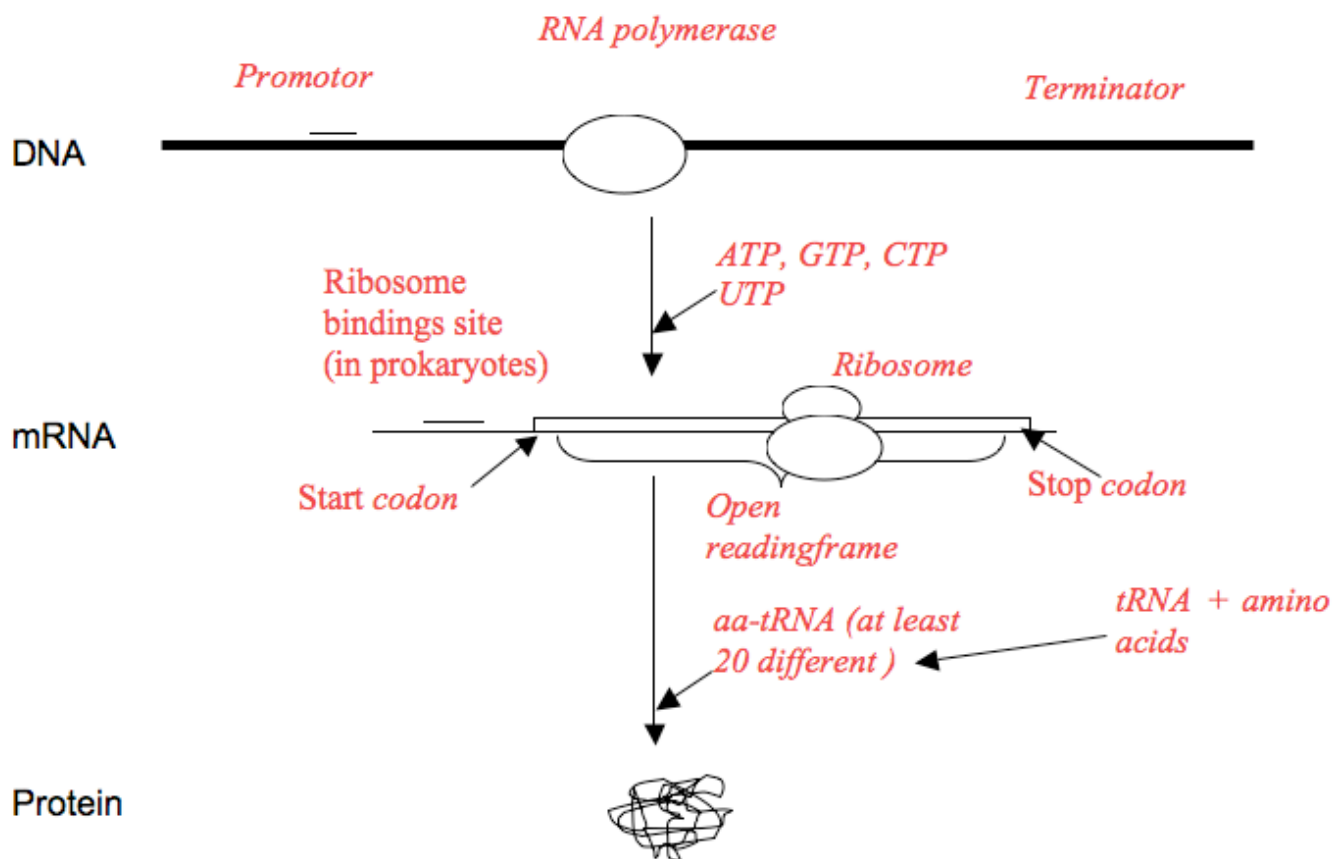
*The protein will be transported to the ER, if the protein contains a signal sequence dictating export to the ER. This kind of signal sequence consists of app. 25 amino acids located to the start of the polypeptide and containing a hydrophobic region. The signal sequence is cleaved from the rest of*

*the protein after its entry into the ER. If a protein does not contain a signal sequence, it will end up in the cytoplasm.*

**Q7.** What decides whether a tRNA carrying an amino acid will be selected as substrate during the translation process?

*The mRNA molecule must have a codon that is complementary to the tRNA molecule's anticodon sequence.*

**Q8.** Write the relevant genetic elements on the DNA and mRNA strands below along with all the enzymes and substrates that are necessary for generating a functional protein:



**Q9.** Describe the central dogma of molecular biology and provide an example of an exception.

*The central dogma of molecular biology describes how information flows from DNA to RNA via transcription and from RNA to protein via translation. An example of an exception is retrovirus (e.g. HIV), the genome of which consists of single-stranded RNA. After an HIV particle has infected a cell, the RNA will be converted into DNA by the enzyme reverse transcriptase and incorporated into the genome of the host cell. Another exception is retrotransposons that are described in ch. 17.*

**Q10.** What is the difference between exons and introns?

*In eukaryotic cells, the primary mRNA transcript (pre-mRNA) contains areas that do not encode amino acids, but are actually removed (spliced out) of the mRNA molecule prior to translation.*

*These areas are called introns. Exons are, on the other hand, areas that are maintained in the mature mRNA molecule, and which encode amino acids.*

**Q11.** Name a couple of amino acids that are hydrophobic.

*Hydrophobic amino acids: Alanine (Ala, A), Isoleucine (Ile, I), Leucine (Leu, L), Valine (Val, V), Methionine (Met, M), Phenylalanine (Phe, F), Tryptophan (Trp, W).*

**Q12.** Name a couple of amino acids that are either positively or negatively charged.

*Positively charged amino acids: Arginine (Arg, R), Histidine (His, H), Lysine (Lys, K).*

*Negatively charged amino acids: Aspartic acid (Asp, D), Glutamic acid (Glu, E).*

**Q13.** Describe primary, secondary, tertiary, and quaternary protein structure.

- *Primary structure: The sequence of amino acids.*
- *Secondary structure: Patterns in which the polypeptide chain folds, e.g.,  $\alpha$ -helixes and  $\beta$ -sheets. NOTE: DNA also folds as a helix, but this is not an  $\alpha$ -helix!!*
- *Tertiary structure: The way the secondary structure elements are placed in relation to each other.*
- *Quaternary structure: When several polypeptides form one protein. NOTE: A polypeptide always consists of one long, continuous chain, while a protein can consist of several polypeptides.*

Typical exam questions (all written material is permitted at the exam).

**Q14.** (1 point).

What does it mean that the genetic code is redundant?

*It means that more than one codon (triplet) encodes the same amino acid. Tryptophan is only encoded by one codon (UGG), while six different codons encode leucine.*

**Q15.** (1 point).

How many possible reading frames does an mRNA molecule contain?

*Three reading frames (e.g., GAUCGAUCGAUCGAUC can be read: **GAU CGA UCG AUC GAU C** (+1 reading frame), **G AUC GAU CGA UCG AUC** (+2 reading frame) and **GA UCG AUC GAU CGA UC** (+3 reading frame)).*

**Q16.** (1 point).

How many possible reading frames does a DNA molecule contain?

*Six (three on each strand).*

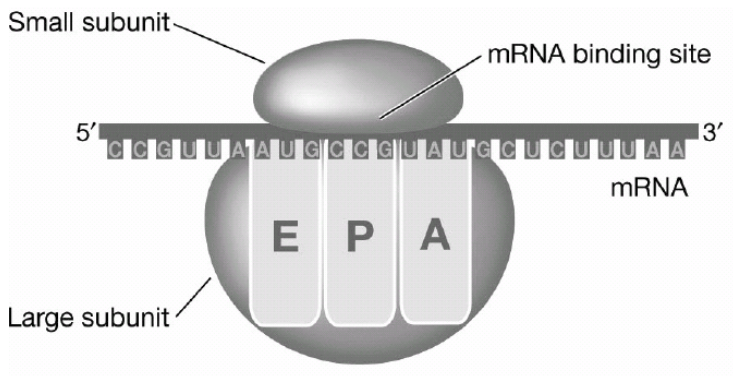
**Q17.** (1 point).

What type of chemical bonds determines the 3-dimensional structure of a tRNA molecule?

*Hydrogen bonds between complementary bases*

**Q18.** (1 point).

Which complex is depicted in the below figure and what is its function?



*It is a ribosome – the translation process takes place here (mRNA is translated to protein).*

**Q19.** (1 point).

Translate the below mRNA string to amino acids using the genetic code. The reading frame is +1.

5' AUGCAUCGGUUAUAA

*M-H-R-L-STOP (Methionine-Histidine-Arginine-Leucine-STOP) (or Methionine-Histidine-Arginine-Leucine).*

**Q20.** (1 point).

Below is shown a piece of the **coding** DNA strand of a gene. Translate the strand to amino acids using the genetic code. The reading frame is +1.

5' ATGTCTTCAAGTTGA

*M-S-S-S-STOP (Methionine-Serine-Serine-Serine-STOP) (or Methionine-Serine-Serine-Serine)*

**Q21.** (1 point).

If a cell is to be active (perform protein synthesis), how many different tRNAs must it minimally contain?

*As a minimum, the cell must contain one codon for each amino acid equivalent to 20 different tRNAs.*

**Q22.** (5 points).

Below is shown 21 bases from the **coding** strand of the  $I^A$  allele of the ABO blood system. This gene encodes the enzyme Transferase A. In total, there are 1,065 coding bases in the  $I^A$  allele. The shown bases are no. 253-273.

5' CTCGTGG**T**GACCCCTTGGCTG

- a) How many amino acids does the Transferase A enzyme consist of?

355 (1065 / 3)

- b) Translate the shown **coding** DNA strand to amino acids using the genetic code. The reading frame is +1. Notice that the first codon is not the start codon, ATG, since the shown bases are not from the beginning of the coding sequence, but base no. 252-272.

*L-V-V-T-P-W-L (Leucine-Valine-Valine-Threonine-Proline-Tryptophan-Leucine).*

- c) The  $i^O$  allele differs from the  $I^A$  allele, since G258 (marked in bold in the shown sequence) has been deleted. Which amino acids does the shown sequence encode, when G258 is deleted?

*L-V-STOP (Leucine-Valine-STOP) or L-V (Leucine-Valine).*

- d) A man, let's call him Paul, has the genotype  $I^A i^O$  within the ABO blood system. What is his blood type?

*Paul has the blood type A.*

- e) Paul has three siblings: Paulette with the blood type AB, Paulus with the blood type B and Peter with the blood type O. Which genotypes do Paul's parents have?

*One parent must be  $I^A i^O$  (blood type A), the other one  $I^B i^O$  (blood type B).*